Research Report 1378

Target Acquisition and Analysis Training System: Evaluation of the Basic Thermal Combat Vehicle Identification (TCVI) Training Program

Norman D. Smith, Gary L. Shope, and Otto H. Heuckeroth
Army Research Institute

William L. Warnick and Stephen S. Essig
Human Resources Research Organization

ARI Field Unit at Fort Hood, Texas
Systems Research Laboratory

U. S. Army

Research Institute for the Behavioral and Social Sciences

November 1987

U. S. ARMY RESEARCH INSTITUTE

FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency under the Jurisdiction of the

Deputy Chief of Staff for Personnel

EDGAR M. JOHNSON
Technical Director

WM. DARRYL HENDERSON
COL, IN
Commanding

Research accomplished under contract
for the Department of the Army

Human Resources Research Organization

Technical review by

David W. Bessemer
Thomas S. Scott

NOTICES

DISTRIBUTION: Primary distribution of this report has been made by ARI. Please address correspondence concerning distribution of reports to: U.S. Army Research Institute for the Behavioral and Social Sciences, ATTN: PERI-POT, 5001 Eisenhower Ave, Alexandria, Virginia 22333-5600.

FINAL DISPOSITION: This report may be destroyed when it is no longer needed. Please do not return it to the U.S. Army Research Institute for the Behavioral and Social Sciences.

NOTE: The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARI Research Report 1378	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) TARGET ACQUISITION AND ANALYSIS TRAINING SYSTEM: EVALUATION OF THE BASIC THERMAL COMBAT VEHICLE IDENTIFICATION (TCVI) TRAINING PROGRAM		5. TYPE OF REPORT & PERIOD COVERED Final Report December 1982-April 1983 6. PERFORMING ORG. REPORT NUMBER --
7. AUTHOR(s) Norman D. Smith, Gary L. Shope and Otto H. Heuckeroth (ARI), William L. Warnick and Stephen S. Essig (HumRRO)		8. CONTRACT OR GRANT NUMBER(s) MDA 903-83-C-0033
9. PERFORMING ORGANIZATION NAME AND ADDRESS Human Resources Research Organization 1100 South Washington Street Alexandria, Virginia 22314		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2Q263744A795 3.2.3.3.1.0.0
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Hood Field Unit, HQ TCATA, Fort Hood, TX 76544-5065		12. REPORT DATE November 1987 13. NUMBER OF PAGES 35
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) U.S. Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Avenue, Alex., VA 22333-5600		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE --

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

--

18. SUPPLEMENTARY NOTES

Contracting Officer's Representative was Norman D. Smith.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Vehicle recognition	Combat Vehicle Identification
Vehicle identification	CVI
Training	
Thermal sights	
Infrared	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Thermal (IR) sighting systems are used on a variety of weapons systems, such as the M1 Tank, the M2 and M3 Infantry Fighting Vehicle, the TOW, and the improved TOW. However, no standard training program that trained the thermal sight operator to recognize or identify the targets with these sights existed. A vehicle recognition and identification training program utilizing simulated thermal images was developed and tested. The Basic Thermal Combat Vehicle Identification (TCVI) Training Program was designed to be compatible with the

(Continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

ARI Research Report 1378

20. ABSTRACT (Continued)

Army's Combat Vehicle Identification (CVI) Training Program (GTA 17-2-9), through use of the same 30 vehicles and training format. The TCVI training was evaluated in the 8th Infantry Division, Germany, where 123 soldiers were pretested, trained, and posttested. Performance was measured by the correct number of vehicle recognition and identification responses. A significant performance change was obtained when a comparison of pretest and posttest scores was made. It was concluded by the TRADOC Combined Arms Center (CAC), the proponent, that the Basic Thermal Combat Vehicle Identification (TCVI) Training Program simulations of thermal images were realistically adequate and that the program was satisfactory for use in training soldiers in vehicle recognition and identification. The program was adopted for Army-wide use as GTA 17-2-10.

Research Report 1378

Target Acquisition and Analysis Training System: Evaluation of the Basic Thermal Combat Vehicle Identification (TCVI) Training Program

Norman D. Smith, Gary L. Shope, and Otto H. Heuckeroth
Army Research Institute

William L. Warnick and Stephen S. Essig
Human Resources Research Organization

ARI Field Unit at Fort Hood, Texas
George M. Gividen, Chief

Systems Research Laboratory
Robin L. Keesee, Director

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

Office, Deputy Chief of Staff for Personnel
Department of the Army

November 1987

Army Project Number
2Q263744A795

Training and Simulation

FOREWORD

The Fort Hood Field Unit of the Army Research Institute (ARI) has developed a series of target recognition and identification (R&I) training programs as part of Task 3.2.1, Target Acquisition and Analysis Training System (TAATS). Both Training and Doctrine Command (TRADOC) and Forces Command (FORSCOM) have recognized the need for standardized R&I training and requested that ARI develop such programs. The programs were developed under the proponency of the Combined Arms Center (CAC), Fort Leavenworth, Kansas.

This report examines the Basic Thermal Combat Vehicle Identification (TCVI) Training Program, the third in a series of four R&I training programs developed by the Fort Hood Field Unit. The TCVI follows the development of the Basic (Photopic) Combat Vehicle Identification (CVI) Training Program and a set of CVI Flash Cards. These three training programs have been adopted as standard training programs by the Army and are designated as GTA 17-2-9 (Basic CVI); GTA 17-2-10 (TCVI); and GTA 17-2-11 (Flash Cards). The fourth program, Advanced (Photopic) CVI Training Program (Masking), was completed and delivered to the Army and awaits production. The evaluation presented here examines the technical and training effectiveness of the Basic TCVI Training Program for use with the Tank Thermal Sight and Thermal Integrated Sight found on the M60A3 and M1 US tanks respectively.

As a result of this assessment, TRADOC adopted and distributed the Basic TCVI Training Program through Training and Audio-visual Support Centers (TASC) for use as the standard Army program.

EDGAR M. JOHNSON
Technical Director

TARGET ACQUISITION AND ANALYSIS TRAINING SYSTEM: EVALUATION OF THE BASIC THERMAL COMBAT VEHICLE IDENTIFICATION (TCVI) TRAINING PROGRAM

EXECUTIVE SUMMARY

Requirement:

The Target Acquisition and Analysis Training System (TAATS) research program was designed to develop a series of logically related training programs in vehicle recognition and identification (R&I). The impetus for such a system was provided by a series of requests dating from 1975 from both Training and Doctrine Command (TRADOC) and Forces Command (FORSCOM). In 1980, an integrated series of training programs was planned in conjunction with the Army's proponent for vehicle recognition, the Combined Arms Center (CAC), Fort Leavenworth, Kansas. The first of the training programs was the Basic Combat Vehicle Identification (CVI) Training Program produced in 1981 and adopted by the Army the same year as its standard R&I training program.

In November 1982 CAC requested that highest priority be given to the development and testing of a Thermal (Infrared) Training Program in response to urgent requests from commanders in Europe and from the Deputy Chief of Staff, Training, at TRADOC. In April 1982 the Basic Thermal CVI Training Program, using simulated thermal images, was completed and tested in Europe. This report briefly reviews the development of the Basic Thermal CVI Training Program and presents the research results from the evaluation.

Procedure:

The Thermal Combat Vehicle Identification (TCVI) Program training was given to 74 tank crewmen of the 8th Infantry Division, U.S. Army Europe. Two locations were selected. At Site One, where 41 men were trained, the objective was to measure performance changes from pretest to posttest on TCVI to determine its effectiveness as a training program. At Site Two, 33 men were trained and measured in a manner similar to that at Site One. However, at Site Two, the primary objective was to determine if order of training (i.e., Basic CVI training first, followed by TCVI training, or vice versa) was important. Both types of training were given, preceded, and followed by the corresponding photopic or thermal test.

Because of the nonavailability of comparable thermal images of NATO and Warsaw Pact combat vehicles, and because of the short time frame, it was necessary to use simulated thermal images. This same nonavailability of actual thermal images of vehicles precluded a formal validation of the program. However, CAC officer evaluators agreed that the simulated images were realistically adequate.

Findings:

Results indicate that the Basic Thermal Combat Vehicle Identification Training Program is an effective training program for use in long-range target R&I with the infrared sights currently on the M1 Abrams and M60A3 tanks. Significant improvements in both recognition and identification scores comparable to the improvements produced by the Basic and Advanced CVI Training Programs (photopic) were demonstrated. Comparison of performance by a group trained on TCVI first and then on CVI with a group given the courses in reverse order indicated no significant differences between the groups.

The findings of this research led to the general conclusions listed below. These conclusions are based upon the assumption that the simulated thermal images used are reasonably valid representations of actual thermal images.

1. The Basic Thermal Combat Vehicle Identification Training Program substantially improves soldier performance in recognizing and identifying thermal images of combat vehicles.

2. For units that are highly motivated to learn combat vehicle identification and that are familiar with thermal sights, especially the Tank Thermal Sight and Tank Integrated Sight, it is not critical to give training on the Basic CVI program before giving training on the Basic Thermal CVI program.

3. Performance on the TCVI program is related to a soldier's General Technical (GT) score.

Utilization of Findings:

Prepublication review of these findings by TRADOC led to the adoption of the Basic Thermal CVI Training Program (GTA 17-2-10) as a standard program for long-range recognition and identification training by the Army.

TARGET ACQUISITION AND ANALYSIS TRAINING SYSTEM: EVALUATION OF THE BASIC THERMAL COMBAT VEHICLE IDENTIFICATION (TCVI) TRAINING PROGRAM

CONTENTS

	Page
INTRODUCTION	1
Background	1
Military Problem	1
Research Solution: The Target Acquisition and Analysis Training System	1
Purpose and Scope of This Research	2
METHOD	3
General Description	3
Vehicle Infrared Images	3
Thermal CVI Simulation Procedure	4
Soldiers Trained	5
Training Procedure	5
Data Collection Instruments	7
Program Description	8
RESULTS	9
Performance Changes Resulting from TCVI Training	9
Comparison of Performance Based on Order of Presentation of the TCVI and Basic CVI Using Data Collected at Site Two	10
Comparison of Performance on Photopic and Thermal Images	10
Comparison of Vehicle View: Front versus Oblique	12
Comparison of Recognition and Identification Performance by GT Grouping	12
DISCUSSIONS AND CONCLUSIONS	15
Discussion	15
General Conclusions	16
REFERENCES	17
APPENDIX A. DATA COLLECTION INSTRUMENTS	A1

LIST OF TABLES

Table 1.	Original data collection schedule for site two	6
2.	Actual schedule for soldiers who completed all elements of training/test at site two	7

CONTENTS (Continued)

Page

Table 3. Comparison of pretest and posttest recognition and identification performance scores at site one 9

4. Effects of order of presentation on performance scores at site two 10

5. Slides recognized and identified by view and image type throughout training at site two 12

6. Relationship of recognition and identification performance on TCVI to GT grouping of soldiers at site two 13

LIST OF FIGURES

Figure 1. Recognition scores for image types and tests 11

2. Identification scores by image types and tests 11

INTRODUCTION

Background

Since World War II, considerable interest has been shown in the problems of target acquisition, such as the detection, recognition and identification of a target sufficiently well to permit the effective employment of weapons. New weapons development has resulted in weapons and fire-control systems that can engage targets at ranges far in excess of the ranges possible with the unaided human eye. Although great technological advances continue to be made, the human eye, when augmented, still provides the best way to recognize and identify targets.

The need for recognition and identification (R&I) programs derives from the diversity of vehicles expected on today's battlefield. Among the many vehicles used by our allies, some look different from ours, and some closely resemble those of nations we consider to be potential threats. Training that improves soldiers' R&I ability will help minimize friendly kills and maximize threat kills.

Military Problem

The demands on human performance in this area of recognition and identification have been increasing in the past several years. It has been generally accepted that the unfriendly (threat) armored forces likely to be engaged by U.S. and other NATO units in a mid-to-high-intensity conflict in Europe will be equipped with antitank missile systems that are both accurate and lethal at ranges extending beyond 3,000 meters. This concern is made even more acute by the expectation that the threat-to-friend force ratio will be quite large (6:1). This general analysis led to increased awareness by the 6th Cavalry Brigade (Air Combat) as well as the Armor School, Fort Knox, and the U.S. Army Intelligence Center and School, Fort Huachuca, that as weapon systems increase in lethality and accuracy, target acquisition performance (recognition and identification) must be improved. It was in this context in 1979 and 1980 that Force Command's Opposing Force Training Detachment, Red Thrust, found that in both the active Army and Reserve components no standard recognition and identification training program existed. In response to these concerns, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI), Fort Hood Field Unit, with the support of the Human Resources Research Organization, Fort Hood (ARI/HumRRO), undertook a research program to investigate systematically the problem of recognition and identification, particularly at extended ranges. The relevant literature is reviewed in some detail by Smith, Heuckeroth, Warnick and Essig (1980).

Research Solution: The Target Acquisition and Analysis Training System

The Target Acquisition and Analysis Training System (TAATS) research program was conceived to provide a logical framework within which to conduct research and to test and develop training programs and devices. TAATS has produced a series of interrelated Combat Vehicle Identification (CVI

Training programs. The first major objective of the CVI Training Program series was to train soldiers to use cues to identify vehicles at realistic combat (engagement and preengagement) ranges. The first program, called the Basic CVI Training Program, presents photopic images of scale model vehicles in open terrain that do not obscure or mask the vehicle (Smith, Heuckeroth, Warnick & Essig, 1980). The advanced CVI Program places the vehicles of the photopic series in hull or turret defilade as they might be viewed in tactical settings (Shope, Smith, Heuckeroth, Warnick & Essig). The CVI training program discussed here-the Basic Thermal Combat Vehicle Identification (TCVI) Training Program-simulates infrared (IR) images as viewed through the Tank Thermal Sight (TTS) and Thermal Integrated Sight (TIS). The design of the materials and procedures for all training packages in the CVI series aims to achieve the following characteristics:

- Provide a controlled, standardized training package.
- Provide a basis for evaluating the level of success reached by soldiers in R&I.
- Allow scheduling flexibility through the design of five-vehicle modules.
- Employ a minimum of support materials to keep training simple and operationally feasible for the military unit.
- Permit training of varying optics/distance requirements in a classroom through simulation procedures.

Purpose and Scope of This Research

This research was designed to evaluate the training effectiveness of the TCVI Training Program. The Basic CVI Training Program performance characteristics were used for comparison with those of the TCVI Training Program.

METHOD

General Description

The research had two major thrusts: (1) to evaluate the effectiveness of the Basic TCVI program on recognition and identification performance; and (2) to determine whether R&I performance is affected if training with Basic CVI or TCVI is used first. Two sites were selected. At Site One, all soldiers were pretested, trained, and posttested only on the TCVI program. At Site Two, all soldiers were pretested, trained with one of the two programs, posttested, trained with the other program, and again posttested.

Vehicle Infrared Images

In order to develop the Basic TCVI program, infrared (IR) images were needed. Assistance was solicited from a variety of in-house laboratories including Nightvision and Electro-optical Laboratory (NV&EOL) as well as through Electro-optical and Infrared Measurements (E-OIR), an ARI contractor. Although the search was thorough, few of the images obtained met the specifications necessary to design a training program. Moreover, it was discovered that a large percentage of the images were taken with the settings on the tank sights adjusted so that any part of the vehicles that radiated heat showed up as white, and other parts of the vehicle were not readily visible. The white-hot image, although extremely good for detection, becomes more blurred than the black hot image and does not hold its shape as well as range increases. Shape is the most critical characteristic for R&I according to a study by Foskett, Baldwin and Kubala, 1978. Ratches and Swistak (1972) noted in a study that in taking pictures of white hot thermal images from the Far Infrared Target Indicator (FIRTI) display that the brightness and contrast adjustments were set for detection, which often "caused blooming of the target which degraded edges of the target. This blooming effect also hurt recognition..."

In addition, technical personnel who worked with thermal sights felt that perceptually the white-hot image was more affected than the black hot image by a large number of conditions such as temperature, ambient lighting, and atmospheric conditions. These factors were alleged to reduce the reliability of the white-hot signatures/cues and increased the number of possible images a soldier would have to learn. For example, if 30 vehicles with five views of each were considered and only three different conditions of temperature, ambient light, visibility (snow, rain, fog) at four ranges (1,000, 1,500, 2,000, 2,500 meters), the number of images needed for training would be 16,200. No R&I training program could be built on such requirements for three reasons. First, the amount of information exceeds the limits of human learning capabilities. Second, the production and funding procedures of Army Training Support Command (ATSC) would almost certainly rule out the use of 35mm slides. This problem argues for a shift to another system such as a sound filmstrip projector system or videodisc/tape with microcomputer control. Although such a solution is technically possible, it was not feasible due to the lack of needed

equipment available to units that need the training. Few if any of them have access to videodisc players or microcomputers and the sound filmstrip system is not currently in the military supply system. The most readily available piece of equipment is a 35mm projector. Recent ARI experience with line units in Europe revealed that even these were hard to find, and replacement parts such as bulbs or trays were often absent. Third, even if the thousands of 35mm slides were produced, management of such an unwieldy program at battalion level would be extremely difficult.

In order to find a solution to the training challenge presented by the white-hot image, ARI's contractor team, HumRRO, took over 3,000 photographs of a limited array of vehicles through the M60A3 and M1 tank IR sights. They found that by changing the polarity switch on the sight to black-hot, the images of most vehicles took on the characteristics of a silhouette that maintained its shape much better than the white-hot image, particularly at longer ranges. This finding minimized the problem of image instability.

One major concern remained: where to acquire black-hot images of the 30 vehicles in the CVI array, photographed through a Tank Integrated Sight or Tank Thermal Sight, and at the specified ranges needed for training? This problem seemed insurmountable given the short time available to produce the TCVI program unless a means of simulating the maximum-high-contrast image in the black-hot setting were possible. Experimentation with actual and simulated thermal images of the M1 tank and the 2 1/2 ton truck resulted in simulated images that were markedly similar to the actual images obtained through the TTS and TIS sights and not easily discriminable by observers. The control resulted in the target being almost totally black and the background lighter. Based upon the knowledge of how to simulate the images of the M1 tank and the 2 1/2 ton truck, simulations were made of all 30 vehicles in the array.

An informal validation of the simulated images was done by the research staff and CAC officers. Although the evaluators felt that the images were realistic and quite adequate, no assertion is made that the simulations used represent all possible images that might be created by various sight settings. While a complete formal validation is desirable, one major factor mitigated a more thorough validation. As discussed earlier, actual thermal images of a significant number of the 30 NATO and Warsaw Pact vehicles were not available, nor was there any possibility of them becoming available within the time constraints imposed on the development of the program. Thermal sights were being installed in all M60A3 tanks in Europe within six months and the development of a thermal sight training program within that six month period was given high priority by commanders there. The validation limits were understood and accepted by CAC.

Thermal CVI Simulation Procedure

A terrain background drawn on paper was placed on a table constructed of matted acrylic plastic shaped to provide an even transition from background to foreground. A reference point was marked on background and each model was placed, in turn, on the reference point. Front and rear lighting were balanced to provide a silhouette image. A video camera was focused on the models and

the video signal was fed to a high-resolution (600-line) monitor. Image size was adjusted to provide compatibility with the CVI sizing template. Photographs were taken of the face of the monitor with a Nikon 35mm camera mounted on a tripod. The film used was Kodak 135-36 Ektachrome 64 professional.

Soldiers Trained

At Site One, 41 soldiers from the 1/68 Armor Battalion situated at Wildfleken, Germany, received TCVI training. The median age of the soldiers was 27 years, with a range of 19 to 50 years. The median number of years of service was 6.4, and the range was .8 to 7.6. The median rank was Staff Sergeant with a range of Private First Class to Master Sergeant. Most of the soldiers, 90%, were from 19E MOS.

At Site Two, 33 soldiers stationed with the 1st Brigade of the 4/69 and 2/28 Armor units at Mainz, Germany, completed the training. The median age was 28.4 years, with a range of 18 to 39 years. The median number of years of service was 10.5 with a range of 1.25 to 15. The median rank was Staff Sergeant with a range from Private First Class to Sergeant First Class. The overwhelming majority of the soldiers at Site Two also held a 19E (70%) or 19D (15%) MOS.

Training Procedure

At both sites, soldiers were tested on a CVI/Thermal test before and after training on 120 slides composed of 60 photopic and 60 simulated thermal images, randomly presented. For both photopic and thermal image slides, there was a front and an obligue view of each of the 30 vehicles in the program.

The data collection plan for Site One was simple and was dictated to a large extent by the needs of the miltary unit. Only thermal training was to be given to tank crews. They were measured before and after training on the CVI/Thermal test. The soldiers were divided into two groups because of the size limitations of the classroom, but were treated analytically as one group.

The original design for Site Two called for 5 groups of 20 each. (See Table 1.) Forty were to be trained with CVI and then TCVI, another 40 in reverse order, and 20 were to serve as an experimental control (receive no training). Following pretesting, soldiers were assigned to groups based on recognition performance scores so that groups were roughly comparable prior to training. However, before training began, a series of changes in this design were necessitated by other demands made on the participating units. The major reason for change was that thermal sights arrived late and had to be installed in preparation for gunnery training. Table 2 describes the actual training/testing schedule that evolved.

Table 1

Original Data Collection Schedule for Site Two

	Pretest	Training	Posttest	Training	Post-posttest
Group 1 n=20	CVI/Thermal	CVI	CVI/Thermal	Thermal	CVI/Thermal
Group 2 n=20	CVI/Thermal	CVI	CVI/Thermal	Thermal	CVI/Thermal
Group 3 n=20	CVI/Thermal	Thermal	CVI/Thermal	CVI	CVI/Thermal
Group 4 n=20	CVI/Thermal	Thermal	CVI/Thermal	CVI	CVI/Thermal
Group 5 n=20	CVI/Thermal	-----	-----	-----	CVI/Thermal

Table 2

Actual Schedule for Soldiers Who Completed All Elements of Training/Test at Site Two

	Pretest	Training	Posttest	Training	Post-posttest
Group 1 n=10	CVI/Thermal 3rd day	CVI 3rd,4th & 5th days 2 mods per day	CVI/Thermal 5th day	Thermal 6th & 7th days 3 mods per day	CVI/Thermal 7th day
Group 2 n=8	CVI/Thermal 3rd day	CVI 5th day 6 mods in one day	CVI/Thermal 6th day	Thermal 6th & 7th days 3 mods per day	CVI/Thermal 7th day
Group 3 n=8	CVI/Thermal 3rd day	Thermal 3rd & 4th day 3 mods per day	CVI/Thermal 4th day	CVI 6th day 6 mods in one day	CVI/Thermal 6th day
Group 4 n=7	CVI/Thermal 3rd day	Thermal 3rd & 4th day 3 mods per day	CVI/Thermal 4th day	CVI 5th day 6 mods in one day	CVI/Thermal 7th day

In summary then, at Site Two, soldiers were assigned to groups based on their pretest recognition scores: groups 1 and 2 received TCVI training first followed by CVI; groups 3 and 4 were trained in reverse order.

In addition to performance scores, information was collected from the soldiers on rank, age, MOS, time in service, and use of corrective lenses for vision. General Technical (GT) scores were obtained directly from the units.

Data Collection Instruments

During training and testing, soldiers were required to make a written response on a prepared answer sheet each time a vehicle image was projected. They had first to make a recognition response--name the vehicle as a friend

(F), threat (T), or "Don't Know" (DK or ?)--and then attempt to identify the vehicle by name (or number) or indicate "Don't Know" (DK or ?). (See Appendix A for examples of the test instruments.) For example, if a Soviet T-62 were projected, the soldier should immediately write the letter "T" for threat and follow it with "T-62".

The "Don't Know" (DK or ?) was used to create a response set that encouraged the soldier to realize that it is often more prudent, if he is uncertain, to make sure what the target is--friend or threat--by looking again or by getting additional information about his sector front. The rationale was that it is better to positively identify the target before shooting, and thus decrease the likelihood of shooting a friend by mistake or shooting prematurely at an enemy. Hence, for a "Don't Know" (DK or ?) response the soldier lost half as many points as for a wrong answer. Very few soldiers availed themselves of this choice. Rather, no response at all was given. Consequently, scoring was done on the basis of one point for a correct response, and no points for a blank or wrong answer.

Program Description

The TCVI training program consists of six training modules and a final test module. Each training module has four views of each of five vehicles. During the module training the IR images are presented in combination with comparable views of the photopic image of each vehicle from the Basic CVI Training Program. The twenty 35mm slides (4 views of 5 vehicles) of each training module are shown twice, once with instructor-determined exposure and a second time for 15 seconds. Each module has a test composed of only IR images of the five vehicles (three views of each) shown for 8 seconds. The final test of the 30 vehicles (2 views each), which uses only the IR image exposed for 8 seconds, provides an overall measure of the training progress. An instructor's manual which contains all the information needed to recognize and identify the vehicle accompanies each module. As in the Basic CVI Program, only key cues are addressed. For a complete description of the TCVI Program see GTA 17-2-10 available from TASO.

In this research a modification was made in the test module in the TCVI program to permit comparison of performance changes resulting from training on the photopic as well as the thermal image. Presentation of the photopic and thermal slides was randomized during the pre- and posttest.

RESULTS

The major questioning deserving analytical attention are (1) comparison of performance characteristics of the TCVI and Basic CVI programs, (2) comparison of performance changes on photopic and thermal images, and (3) evaluation of performance changes related to GT score.

Performance Changes Resulting from TCVI Training

Two analyses of variance were done with soldiers' pretest and posttest scores using the TCVI data collected at Site One, Wildfleckin. A significant improvement in performance was found for both recognition, $F(1, 40) = 61.67$, $p < .001$, and identification, $F(1, 40) = 108.62$, $p < .001$. Means and standard deviations to support these findings, as presented in Table 3, indicate significant overall improvement in recognition and identification performance as a result of using the TCVI program. The markedly larger standard deviations for posttest performance imply that the program is not equally effective for all participants. Some of this differential may be related to a soldier's GT score. An analysis addressing this factor is covered later in this section.

Table 3

Comparison of Pretest and Post-Test Recognition and Identification Performance Scores[a] at Site One (n=41)

	Recognition		Identification	
	M	SD	M	SD
Pretest	81.90	1.46	18.61	6.68
Posttest	97.10	13.78	40.69	17.68

[a] Maximum possible score is 120. Means represent average number of correct responses to two photopic (max = 60 slides) and two thermal (max = 60 slides) images presented in a randomized other within each test session.

It is worth noting here that although this performance appears low, repeated training utilizing the CVI programs would produce significantly faster learning, as noted in recent research by Smith, Heuckeroth, Shope, & Warnick, 1984. In this research soldiers were trained repeatedly on 10, 15, and 20 vehicles. For the 20-vehicle group, 87% were learned in four training periods; for the 15-vehicle and 10-vehicle groups, respectively, 86% and 89% were learned in three training periods.

Comparison of Performance Based on Order of Presentation of the TCVI and Basic CVI Using Data Collected of Site Two

Although the Basic CVI and the TCVI training programs are similar, it is reasonable to question whether the Basic CVI should be taught first or whether the TCVI can be used alone. In order to address this question, performance on, the post-posttest—the test administerd after training with both programs had been completed--was examined using data collected at Site Two. Mean performance on the photopic image for recognition under program order--Thermal/CVI--was compared with its counterpart under program order--CVI/Thermal. Also, photopic means for identification were compared, and similar comparisons for the thermal image were made. In each of the four comparisons, the t statistic failed to attain significance ($p > .05$). The inference to be drawn from these tests is that Basic CVI training is not mandatory as preparation for the use of the TCVI. However, the most common order for training is to present the Basic CVI program first followed by TCVI. Supporting means and standard deviations are presented in Table 4.

Table 4

Effects of Order of Presentation on Performance Scores[a] At Site Two

Program order used	Thermal/CVI (n=15)				CVI/Thermal (n=18)			
Measure:	Recognition		Identification		Recognition		Identification	
Type of image	M	SD	M	SD	M	SD	M	SD
Photopic	52.00	6.70	31.07	14.26	46.67	10.08	27.44	15.17
Thermal	46.00	6.28	19.67	10.38	44.50	9.69	23.17	13.28

[a]Total possible score was 60. These means are not directly additive with those in Table 3 because of the unequal sample sizes.

Comparison of Performance on Photopic and Thermal Images

In the Basic CVI Training Program (GTA 17-2-9) in standard use throughout the Army, only the photopic image is employed. As noted earlier, the TCVI pairs the photopic and thermal images in training and as individually randomly distributed slides during testing. A comparison of the performance on the two types of images provides a basis for infering whether, on the average, each type of image is equally easy to learn. Presence of an interaction between

image type and test implies that R&I skills are not equally easy to acquire with each type of image. With recognition a significant interaction is found [$F(1, 40) = 8.22, p < .007$]. Figure 1 shows performance changes between pre- and posttests for photopic (white bar) and thermal images (black bar). The relatively poorer pretest performance for thermal images is probably due to the relative unfamiliarity of the soldiers with the thermal image. Performance increases through training to the point where thermal and photopic images have been learned equally well.

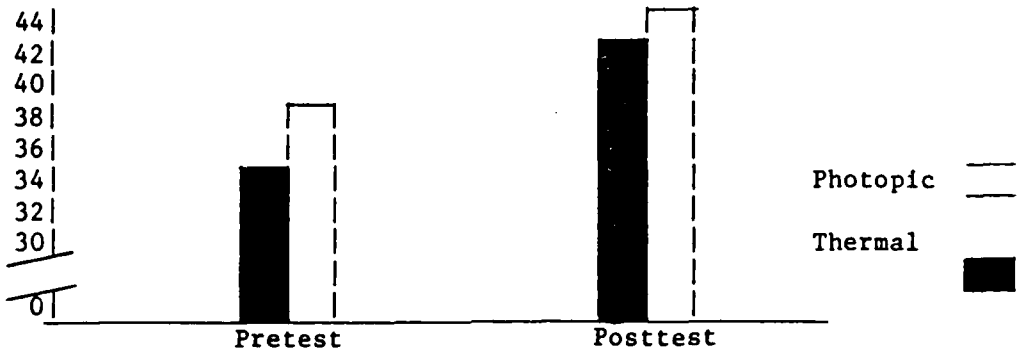

Figure 1. Recognition scores for image types and tests.

A similar analysis of photopic and thermal images using pre- and posttest scores for identification did not result in a significant interaction [$F(1,40) = 2.02, p > .16$]. (See Figure 2). This finding together with the supporting data in Figure 2, indicates that while initial pretest identification performance is poorer for thermal images (as for recognition performance) training improves identification performance almost equally for both image types.

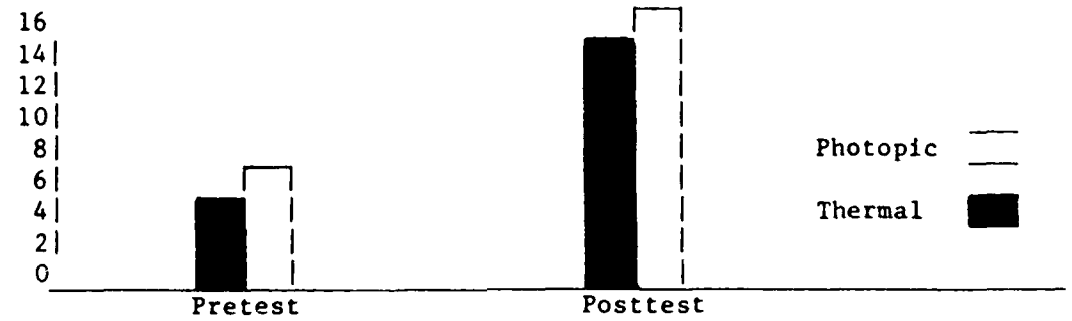

Figure 2. Identification scores for image types and tests.

Comparison of Vehicle View: Front versus Oblique

Contrasting the scores on front and oblique views of vehicles indicated significantly poorer performance on front views; for recognition [$F(1, 32) = 238.65$, $p < .001$] and for identification, [$F(1, 32) = 148.35$, $p < .001$]. Image type by view interactions for both recognition and identification were significant, [$F(1, 32) = 25.04$, $p < .001$] and [$F(1, 32) = 21.94$, $p < .001$], respectively. Means and standard deviations to support these analyses are presented in Table 5. Examination of results presented in Table 5 indicate that although both recognition and identification performance are poorer for thermal images for each type of view, performance on the oblique view is more comparable for both image types--before and after training.

Table 5

Slides Recognized and Identified by View and Image Type Throughout Training at Site Two (n=33)

	Photopic				Thermal			
	Recognition		Identification		Recognition		Identification	
	M	SD	M	SD	M	SD	M	SD
Pretest								
Front	17.55	4.45	2.64	4.02	14.00	3.98	0.85	1.52
Oblique	21.45	4.41	5.21	5.50	20.60	3.55	4.52	4.38
Posttest								
Front	21.45	4.99	9.55	7.09	17.58	5.47	4.15	3.90
Oblique	25.52	4.52	14.09	8.35	23.55	4.44	10.70	7.00
Post-posttest								
Front	22.88	5.02	11.85	6.84	19.61	5.09	6.61	4.82
Oblique	26.21	4.20	17.24	8.23	25.58	4.21	14.97	7.51

Comparison of Recognition and Identification Performance by GT Grouping

Data from Site Two were used to perform two analyses of variance using three categories of GT scores (115-133, 100-114, and 76-99) and three test periods (pretest, posttest, and post-posttest). Over all test periods, significant performance differences were found among GT categories; for recognition [$F(2, 25) = 3.30$, $p = .05$] and for identification [$F(2, 25) = 8.46$, $p = .002$). Although no test period by GT interaction resulted with recognition ($F < 1$), a significant effect was found with identification [$F(4, 50) = 6.73$, $p < .001$]. This interaction is apparently due to the relatively slower rate of performance improvement between test periods for the

Table 6

Relationship of Recognition and Identification Performance on TCVI to GT Grouping of Soldiers at Site Two[a]

Test	Recognition						Identification					
	GT Scores						GT Scores					
	115 - 133 (n=8)		100 - 114 (n=10)		76 - 99 (n=10)		115 - 133 (n=8)		100 - 114 (n=10)		76 - 99 (n=10)	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Pretest	74.75	15.23	79.80	6.36	67.60	18.63	25.38	20.16	15.60	13.15	5.90	6.69
Posttest	88.50	17.43	95.40	11.01	79.60	22.62	57.13	25.96	51.10	20.51	17.30	13.90
Post-posttest	97.88	11.87	103.30	8.65	84.20	21.36	65.75	27.22	64.70	21.36	32.30	15.23

Note. Total possible score is 120. For recognition, a score of 60 is possible by chance.

[a]Five GT scores not reported.

lowest GT category soldiers. A Duncan Multiple Range Test for the identification means for the posttest (See Table 6) indicated that soldiers with GT above 100 did significantly better ($p < .05$); the differences between the top two GT categories was not significant.

DISCUSSION AND CONCLUSIONS

Discussion

There was serious doubt during the problem definition stage whether an effective thermal training program of any type could be produced. Experts in the IR field pointed to the gross instability in the white-hot signature. The signature was affected by ambient temperature, vehicle engine placement, appendages to the vehicle (such as the splash shield on the M113), precipitation, time of day, and skill of the operator in making adjustments on the IR sight itself, to name but a few factors. Extensive review of white-hot IR images acquired by a variety of means underscored the problem. The white-hot signature alone did not show sufficient stability or provide adequate information about the vehicle shape at longer engagement ranges to permit organization by trainers into learnable "chunks." For example, it would have required several thousand slides to encompass the possible image changes of a single vehicle under various conditions.

After reviewing the available information, the ARI technical support team from HumRRO experimented photographically with images through IR sights and found that a high contrast black-hot setting mitigated the deficiences of the white-hot image. Only then was it possible to conclude that a training program could be produced in the limited time made available.

The Basic Thermal Combat Vehicle Identification (TCVI) Training Program was developed, tested, and turned over to the Army in less than 8 months. The design is similar to the Basic Combat Vehicle Identification (CVI) Training Program developed earlier (now the Army's standardized program). Hence, TCVI is one of several training programs that build on each other and thus reflect an effort to develop a systematic training approach to target acquisition and analysis.

A significant improvement was found after training. Since no other programs exist, comparisons were impossible. The TCVI shares similar objectives with the several CVI programs: to keep training simple with a minimum of support materials, to train soldiers to recognize primarily those cues that are important at realistic combat ranges, and to be modular in design for use in short training periods. These objectives were achieved. In Europe, with battalion-size combat arms units, the importance of keeping the support requirements simple was underscored. While it may ultimately be desirable to have interactive computers and videodisc/videotape technology for training, it may be some time before this equipment is generally available at the battalion level. In the interim, soldiers must be trained and the TCVI program makes this training possible.

Average pretest scores were higher in Europe than in The Continental United States (CONUS). Recognition mean percent correct was 77% in Europe and 58% in CONUS; identification was 45% versus 13%. While the basis for comparison is not entirely the same, the differences do suggest that the troops tested in Europe have greater familiarity with more of the vehicles in the CVI

program than the soldiers in our CONUS research. This fact can probably be accounted for by a combination of factors: NATO vehicles are seen more often, R&I training is given more often, and there is more interest in knowing Soviet and NATO vehicles because of the closer proximity to potentially life-threatening circumstances.

An interesting finding is that performance decreases significantly as GT scores fall below 100. This effect is more apparent with identification than recognition because the probability of being right on recognition is 50/50 but only 1/30 in identification. The performance decrement has implications for training and research. First, it may be necessary to make provision for personnel below the GT level of 100 to receive more CVI training. Second, additional research is needed to be certain that poor motivation does not account for part of the decreased performance. A study that examines motivation, both intrinsic and extrinsic, in the context of GT levels will soon be completed. A third consideration is the relationship between GT level and long-term memory with specific attention to how frequently training must be repeated. Research on this subject is now in progress.

It is highly desirable to determine how much generalization takes place from any training to the real situation. To accomplish this evaluation, the National Training Center (NTC) has been considered, but the array of vehicles there is limited. NTC includes a visual modification of the M551 to resemble several Soviet vehicles such as the T-72; a few Soviet vehicles are situated in static positions for visual effect, but no NATO vehicles are present. Hence, a real test of the CVI program is not possible at the NTC. Furthermore,the cost of conducting a field test involving the 30 CVI vehicles might very well exceed the probable value of knowing whether 70%, 80%, or 100% of what is learned transfers to the field. A good review of the literature on how much generalization results from costly simulators is found in Specification of Training Simulator Fidelity: A Research Plan by Baum et al. (1982). Hence, until resources are made available, the estimate of training generalization must rest primarily on face validity.

General Conclusions

The findings of this research led to the following general conclusions. These conclusions are based upon the assumption that the simulated thermal images utilized in the TCVI program are reasonably valid representations of actual thermal images.

- The Basic Thermal Combat Vehicle Identification (TCVI) Training Program substantially improves soldier performance in recognizing and identifying thermal images of combat vehicles.

- For units that are highly motivated to learn combat vehicles and who are familiar with thermal sights, especially the TIS and TTS, (e.g., as troops in armor units in Europe) it is not critical to give training on the Basic CVI Program before training is given on the Basic Thermal CVI Program.

- Performance on the TCVI Program is related to GT scores.

REFERENCES

Baum, D. R., Smith, D. A., Hirschfeld, C. A., Klein, C. A., Swezey, R. W., & Harp, R. T. (1982). Specification of training simulator fidelity: A research plan (Technical Report 558). U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A127 346)

Foskett, R. J., Baldwin, R. D., & Kubala, A. L. (1978). The detection ranges of features of armored vehicles (Technical Report TR-78-A37). U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A068 043)

Ratches, J. & Swistak, J. (1972). Thermal systems' performance evaluation using photographic thermal imagery (Technical Report 7014). U.S. Army Electronics Command.

Shope, G. L., Smith, N. D., Heuckeroth, O. H., Warnick, W. L., & Essig, S. S. (1982). Evaluation of an advanced combat vehicle identification (CVI) training program (masking): A new approach to target acquisition training (Research Report 1368). U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A148 911)

Shope, G. L., Smith, N. D., & Heuckeroth, O. H. (1984). Target acquisition and analysis training system: Verbal proficiency, GT and training readiness as performance predicators on the Basic Combat Vehicle Identification Training Program (Technical Report 622). U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A169 194)

Smith, N. D., Heuckeroth, O. H., Warnick, W. L., & Essig, S. S. (1980). Evaluation of a new approach to target acquisition training: The Combat Vehicle Identification (CVI) Training Program (Research Report 1304). U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A111 732)

Smith, N. D., Heuckeroth, O. H., Shope, G. L., & Warnick, W. L. (1984). Target acquisition and analysis training system: Evaluation of massed training and module size. U.S. Army Research Institute for the Behavioral and Social Sciences. (In preparation.)

APPENDIX A

Data Collection Instruments

Name/Rank _____ Date _____

Unit _____ Module No. _____

BASIC THERMAL COMBAT VEHICLE IDENTIFICATION (TCVI)
TRAINING PROGRAM

Example: Other pages differ only in this heading and in slide number.

Soldier Work Sheet
Modules 1-6

Section A: Manual Presentation Sequence

Slide	Friend/Threat	Vehicle Description
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Name/Rank _____ Date _____

Unit _____ Module No. _____

Soldier Work Sheet
Section B: Automated Presentation Sequence

Slide	Friend/Threat	Vehicle Description
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		

Name/Rank _____ Date _____

Unit _____ Module No. _____

Soldier Test Answer Sheet
Section C: Module Test

Slide	Friend/Threat	Vehicle Description
41		
42		
43		
44		
45		
46		
47		
48		
49		
50		
51		
52		
53		
54		
55		
56		
57		
58		
59		
60		

Name/Rank _____ Date _____

Unit _____ Module No. _____

Soldier Test Answer Sheet (Page 1)
Module 7

Final Test

Slide	Friend/Threat	Vehicle Description
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Name/Rank _____ Date _____

Unit _____ Module No. _____

Soldier Test Answer Sheet (Page 2)
Module 7

Slide	Friend/Threat	Vehicle Description
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		

Name/Rank _____ Date _____

Unit _____ Module No. _____

Soldier Test Answer Sheet (Page 1)
Module 7

Slide	Friend/Threat	Vehicle Description
41	_____	_____
42	_____	_____
43	_____	_____
44	_____	_____
45	_____	_____
46	_____	_____
47	_____	_____
48	_____	_____
49	_____	_____
50	_____	_____
51	_____	_____
52	_____	_____
53	_____	_____
54	_____	_____
55	_____	_____
56	_____	_____
57	_____	_____
58	_____	_____
59	_____	_____
60	_____	_____